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THE UK MOD APPROACH TO THE REDUCTION OF VOC'S AT SERVICE BASES

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ABSTRACT

Environmental legislation has forced the Royal Air Force, Army and Royal Navy to perform a critical and comprehensive review of both the processes they undertake and the types of materials they use. The paints and coatings world, in particular, faces many challenges and the UK MOD as a significant user of paints and paint removers has to address the problems associated with meeting environmental pressures whilst retaining existing performance criteria.

This paper will outline the legislation contained within the Environmental Protection Act (EPA) which has been introduced to control the atmospheric discharge of volatile organic compounds (VOCs) and will highlight the consequent implications to the UK MOD. The alternative technical solutions to ensure compliance with the legal requirements including 'Compliant Coatings' will be discussed.

Although the UK MOD faces many challenges within the painting and paint removal field, this paper will concentrate on the refinishing of military vehicles and aircraft and associated processes. These are priority areas, as this process involves a significant consumption of paint materials and, therefore, high volumes of VOC. Work undertaken to introduce compliant coatings as alternatives to traditional solvent based products is detailed and the programme highlights the effective co-operation between the Defence Evaluation & Research Agency (DERA), Army and Royal Air Force Departments and the Directorate of Standardisation. The approach by these departments to reduce the consumption of VOCs from supplementary processes to painting are also outlined. In addition, a brief review of the approach adopted by the Royal Navy will be discussed.

As part of the process the various phases of the project will be discussed. This covers the definition of MOD requirements, which can be unique to the Defence arena. It will review laboratory based performance testing, user trials of the materials and the development of the materials specification concluding with the production of Standards for the materials.

INTRODUCTION

All industrial sectors are being forced to review the potential impact of their business on the environment. In addition to specific legislation, enhanced public awareness is driving companies and government departments to review the various processes they undertake and the UK MOD, although an extremely complex organisation with a

huge range of tasks and responsibilities, is not immune from embracing the changes required of Industry in general.

One area in which environmental legislation has had a major impact is in the drive to reduce the levels of organic solvents contained in paints and paint removers. This is a major issue for the UK MOD as both the procurement process and the in-service operation of defence equipment will involve painting and re-painting processes at prime contractors and at service bases in various global locations.

To address the environmental challenge, the three services of the MOD have initiated programmes, supported by the Defence Evaluation & Research Agency (DERA), to introduce materials that comply with UK legislation without any reduction in performance. This work has included the standardization activity necessary in order to procure materials, under competitive tender conditions, for service use.

LEGISLATIVE BACKGROUND

The historical development of paints has seen compositional modifications in response to an awareness of environmental and health and safety issues - reductions in the use of lead is an example. During the 1990s, the pressure has increased and legislation is becoming more restrictive. In particular, the introduction of the Environmental Protection Act 1990 (EPA) has had considerable ramifications within the paint industry. The EPA is a wide ranging act and a major part of the document covers the discharge of harmful substances to air, water and land. It includes the atmospheric discharge of volatile organic compounds (VOCs). VOCs are, in general terms, organic solvents with boiling points below 110°C and it has been established that these contribute to the formation of low level ozone pollution, which has health implications to the general population. VOCs also pose Health & Safety hazards to operators using these materials.

As a major part of the EPA is aimed at reducing the discharge of VOCs, it places significant pressures on the use of traditional paint materials as these formulations generally contain significant quantities of solvents. Solvents provide the carrier medium for the film forming binder/pigment composition and allow the paint to transfer to the selected substrate, by the selected application method, before evaporating during the drying stage.

As painting and related processes are used in a wide range of industrial finishing applications, a set of Process Guidance (PG) notes have been issued by the Department of the Environment to assist with the implementation of the EPA. The PGs cover activities such as 'Coating and Recoating of Aircraft and Aircraft Components' (PG 6/40), 'Paint Application in Vehicle Manufacturing' (PG 6/20) and non-specific painting processes are covered in the general 'Coating of Metal and Plastic' (PG 6/23). The PG documents also contain guidance on the use of materials at the surface pre-treatment and paint removal stages.

The criterion for regulation enforcement is the volume of solvent based cleaners, paint and paint removers used during the process and if the levels are below certain limits that particular installation would be excluded from the requirements of the relevant PG. This emphasises the need to record the quantities of solvent based (VOC) products used, as it is a common misconception that all painting processes need to be modified to conform to forthcoming regulations.

If the audited records confirm that the quantities of paint used exceed the limits within the PG, the user needs to consider two options to reduce the VOC discharge to the atmosphere. The VOC emissions can either be reduced through the installation of an arrestment plant that captures the pollutants or, alternatively, the user can specify the use of 'compliant coatings'. Compliant coatings are defined as products which contain less than the maximum permissible VOC level for that class of product listed in the relevant PG. With a few specific exceptions, the compliant level has a significantly reduced VOC content.

ALTERNATIVE SOLUTIONS

Although end of pipe abatement is a valid alternative for reducing VOC discharge, the plant required is very expensive and is, in many applications, an impractical alternative for MOD units. Arrestment plants rely on absorption, condensation or incineration processes but absorption and condensation techniques are preferred as they offer recovery of the solvent. This solution may be desirable in dedicated paint shops, particularly where production painting rates are very high, in which the investment would be returned and some industrial sites have chosen this solution e.g. automotive finishing plants.

MOD users have decided to pursue the compliant coatings route – as recommended in the PGs. These do not involve the investment of expensive arrestment plant although this new generation of materials may prove to have a more expensive unit cost than the solvent based products in the short term. Compliant coatings can, however, be considered a greener technology, which reduce the VOC content at source. It is important to realise, however, that the PG documents, in general, impose limits on coatings, which are increasingly restrictive with the 1998 figures having limits, which are lower than the 1996 targets.

Limits are expressed as grams per litre (g/l) of VOC content within the paint and typical limits are:

	1998 limits (PG6/23 January 1995)	Typical current paint formulation
General Primer	250g/l	450g/l
Top Coat	420g/l	560g/l

The precise definition of a compliant coating is contained within the relevant PG of interest. In general, it means that the paint product has a reduced solvent content, although it is recognised that in certain circumstances the adoption of a solvent reduced alternative is not possible in the immediate short term and some coatings may prove to be 'compliant' with existing product technology. To reduce the solvent content various alternatives are available to the paint manufacturer but two principle materials are being offered:

- a. High Solids Paints - Solvent levels are reduced by increasing the solid content (typically 60-80% solids are used). To retain a product with acceptable rheological properties further formulation changes may be required which can affect other properties of the material;

- b. Water Based Paints - These essentially use water instead of an organic solvent as the carrying medium although other formulation changes are required to cope with such a significant change in the chemistry of the paint system. Small quantities of solvent still remain within most formulations but these materials could be classed as a greener alternative than high solids products. Examples of this product include decorative emulsions common to many domestic situations.

As direct replacements for solvent-based products, paint manufacturers have developed products which are either high solids or water based. In fact the appropriate route to follow has caused considerable debate in the paint industry.

Other types of paint technology which can be used to overcome solvent use are powder coatings which are paint formulations in powder form which are cured thermally - these products have no solvent content at all. Radiation cured coatings are also an alternative in which the paints (in wet form) are cured using radiation such as UV or even electron beam - this method of curing requires less energy than thermally cured materials. Although radiation cured coatings have not been used by the MOD, powder coating materials are used for finishing certain components where the item is suitable for stoving at high temperatures.

The remainder of this section covers the technical assessment and introduction of compliant coatings as alternatives to the solvent based products used in Defence applications. Different PG documents, and hence different definitions of compliant coatings, cover the various MOD Departments and the areas are, therefore, covered separately.

PAINTS FOR LAND VEHICLES

Platforms in this category include front line (tanks, armoured vehicles etc) and support vehicles. Both the Army and the RAF have an interest in such equipment and the DERA has supported the Army Technical Support Authority (ATSA), the branch responsible for maintenance painting at Army Base Workshops, and the RAF Surface Finishing Authority (SM35f(RAF)) with the introduction of compliant materials.

The paint scheme with the highest volume use in this area is the Nato Green Infra Red Reflecting finish applied to most vehicles and support equipment and this is specified by the Defence Standard 80-41¹. This specification details a paint scheme consisting of a primer, undercoat and two finish coats, i.e. a four-coat system. It is an essentially performance based specification listing the requirements of the scheme - covering a range of properties. In addition to corrosion resistance and other standard paint film properties, a critical requirement of this material is the camouflage attributes that need to be retained in any alternative product. It is also critical that the material is easily applied by brush as Army units undertake touch-up operations under non-workshop conditions.

The laboratory work undertaken has involved the testing of compliant products (mainly water based to achieve the 250g/l primer limit within the PG) offered by paint manufacturers against a draft Defence Standard containing the same tests as 80-41. The performance assessment covers a range of physical, mechanical, corrosion and durability tests of the coating - examples include the scratch test, salt spray test and fuel resistance test. In addition, the suitability of the products for maintenance

painting was evaluated. A maintenance situation, unlike original equipment painting, often involves application to surfaces that are less than perfectly clean. Many of the water-based products were less than satisfactory in this role. Overall, results to date have not yielded suitable direct alternatives to the traditional materials.

More recently, products used as car refinishing materials have been assessed with satisfactory performance results. The use of such commercial products is a logical step to follow but to ensure that the MOD needs would not be compromised, laboratory work has been undertaken together with trials to assess the in-service aspects of the materials.

A change in MOD policy and the availability of improved finishing facilities has also opened the route for the greater use of two pack materials for land side vehicles and consequently the Army Technical Support Authority have initiated work to introduce high solids polyurethane materials into service. As a result of this work, a set of new performance standards have been developed and issued ².

Following extensive laboratory work and user trials, materials were identified which met service requirements. This phase of work involved considerable dialogue with paint manufacturers to refine their product formulations to meet the required performance.

To ensure consistency of supply and enable competitive tendering, four Interim Defence Standard have been developed to cover the procurement of these materials with the results from the practical work used to provide performance limits on the materials. These have recently been published and can be used as replacements for older Defence Standards that allowed high VOC products. The new standards are detailed below:

Defence Standard	Product Description	Description of Use	Standard replaced where a compliant coating is needed *
INT DS 80-206/1	Paint, Priming, Zinc Phosphate, Two-Pack Epoxy, Non-Aircraft Use, Low VOC	Primer for ferrous based vehicles	Defence Standard 80-114 Defence Standard 80-126
INT DS 80-207/1	Paint, Priming, Zinc Chromate, Two-Pack Epoxy, Non-Aircraft Use, Low VOC	Primer for aluminium and aluminium alloy based vehicles	Defence Standard 80-114 Defence Standard 80-5
INT DS 80-208/1	Paint, Finishing, Polyurethane, Multi-Pack, Matt, IRR, Non-Aircraft Use, Low VOC	Matt finish for vehicles with IRR camouflage properties	Defence Standard 80-41 Defence Standard 80-166
INT DS 80-209/1	Paint, Finishing, Polyurethane, Multi-Pack, Gloss, Non-Aircraft Use, Low VOC	Gloss finish for Vehicles	Defence Standard 80-50

- * These standards will not be withdrawn for the foreseeable future, as there will be a reducing need for these materials over the next few years

These materials are based on chemically curing, high build epoxy and polyurethane resin systems and offer performance enhancements on the single pack materials specified in the older standards. For example, the new paint schemes consist of two coats resulting in lower VOCs and a simplified application process, whilst offering increased durability. However, the use of these materials is significantly different to the older materials. For example, the polyurethane materials necessitate a spray facility with specific ventilation requirements and, therefore, have to be undertaken at approved locations only. Consequently these materials cannot be used as 'touch-up' products, although the improved durability and mechanical performance should ensure that damage and deterioration does not occur as rapidly as in the past. However, DERA has investigated the use of 'touch-up' kits, based on two pack epoxy primer and finish coats, to provide materials for the repair of damaged paintwork.

The development of these standards has proved to be an excellent example of a productive interaction between paint users, equipment support authorities, the Directorate of Standardization, DERA and the paint industry. As a result, the MOD has products available which meet current environmental legislation and demonstrate a commitment to green issues whilst enhancing material performance.

At the international level, NATO are also very interested in using compliant materials, not only to ensure compliance with member Nation's Government regulations, but to increase the confidence and interoperability between individual Nation's products in the Operational field. NATO Committee AC/301 Sub Group B - Standardization of Materiel and Engineering Practices, deals with paint related STANAGs (NATO Standards) and it is currently working on two STANAGs which will specify compliant materials. Both relate to Chemical Agent Resistant Coatings:

STANAG 4360 - Specification for Paints and Paint Systems, Resistant to Chemical Agents and Decontaminants, for the Protection of Land Military Equipment.

STANAG 4477 - Specification for Paints and Paint Systems, Resistant to Chemical Agents and Decontaminants, for the Protection of Aerospace Military Equipment.

At present, both STANAGs as they stand are unsuitable for UK MOD use, but with modification their usability could be increased to a level where Defence Standard's 80-208 & 80-209 could be cancelled in favour of the NATO product specifications. Not only would this be in line with UK MOD Standardization policy, but it would also increase UK MOD's procurement capability.

To further address the reduction of VOC usage during the painting of land vehicles, the supplementary processes involved with painting have been reviewed. Equipment is washed using a water/detergent mix prior to mechanical preparation with only localised solvent degreasing for difficult areas.

Paint spraying application methods are also covered in relevant PGs and to improve transfer efficiency and reduce waste, High Volume Low Pressure (HVLP) is specified

as the minimum acceptable technique. HVLP guns have been introduced and some Army Base Workshops are investing in electrostatic spray equipment with its improved transfer efficiency over HVLP facilities. This offers improvements to both the environment and the paint applicators and the reduction in waste has cost benefits.

With regard to paint removal, land vehicles are stripped using mechanical methods rather than VOC based chemicals.

Additional measures to reduce solvent emissions and waste, involve the use of solvent recovery units to reuse waste materials and enclosed cleaning plants are employed to clean spray guns.

AIRCRAFT PAINTS

A separate PG (PG 6/40 ³) covers the repainting of aircraft. This document has a range of VOC limits depending on the exact nature of the paint product and examples include the following:

Material	Limit
Epoxy Primer	350g/l
Gloss polyurethane	420g/l
Erosion resistant coatings	800g/l
'Other speciality Coatings'	840g/l

The most commonly used materials by the RAF for aircraft refinishing are epoxy based primers based around the British Standard specification (BSX 33) and matt polyurethane top coats based around the British Standard specification (BSX 34).

The matt polyurethane topcoats used by the RAF are classed as 'Other speciality coatings' due to the necessary camouflage requirements. These have a relatively high VOC limit and current materials meet this level easing the pressure on a significant part of the RAF paint inventory. However, the RAF are evaluating high solids matt polyurethane finish coats for future use so that these products provide a genuine reduction in VOC content.

There are, however, other paints with lower VOC limits (e.g. abrasion resistant coatings) for which compliant materials will need to be identified and evaluated. For the limited number of aircraft requiring a gloss polyurethane finish, the RAF are using high solids VOC compliant finish with less than 420g/l.

Following extensive materials evaluation programmes, the RAF Surface Finishing Authority (SM35f (RAF)) are now using compliant materials for their most commonly used aircraft paint systems with the materials applied using HVLP equipment.

Paint removal on aircraft has traditionally been carried out by chemical methods using dichloromethane based paint removers. Over the last five years the RAF has adopted physical methods of paint removal using plastic media stripping (PMS). Under PG 6/40, dichloromethane based paint removers are not compliant and to cover the areas that still require a chemical stripper, products based on benzyl alcohol, which is a non-VOC materials as defined in the PG, are being evaluated.

Whilst these have been successful with selectively strippable paint schemes, they are generally not effective on conventional polyurethane based aircraft finishes. Further work is required in this area.

Degreasing of aircraft, prior to painting, is another area in which work is ongoing to partially reduce the current reliance on solvent-based products.

On the subject of aircraft paint schemes, but separate to the pressure on solvent reduction is the increasing environmental concern with the use of chromates within aircraft primer formulations. Chromates are extensively used for the corrosion protection they offer to critical non-ferrous based metal substrates, however, the environmental impact of such heavy metals is causing increasing concern. To address this problem experimental paint formulations containing chromate replacements are being assessed against current chromate products by the DERA.

PAINTS FOR NAVAL EQUIPMENT

The Royal Navy has adopted a very proactive response to environmental concerns. In common with the other Services, priority has been placed on the high volume use materials and these include the weatherwork coatings applied to the superstructure of ships, flight deck coatings and paints schemes used on the internal surfaces of vessels. Work has involved laboratory evaluations and ship trials and a paper by Townsend ⁴ describes, in greater detail, the trial work undertaken.

The laboratory work undertaken to date has concentrated on the evaluation of high solids and water based materials against the Defence Standards covering the weatherwork paint system. This material has a number of critical requirements including the achievement, and retention, of high gloss levels. It is also a material that may be applied under adverse conditions using unsophisticated equipment during naval operations. Further work is also underway to investigate coatings used for internal applications and on flight decks and any new coatings introduced into service have to meet future environmental legislation in addition to meeting other technical requirements.

CONCLUSIONS

Environmental legislation has provided a major impetus to introduce new coatings but in addition to the introduction of materials with low solvent contents it has provided an opportunity to introduce materials with improved performance.

This has been shown to good effect in the vehicle finishing area in which the armed forces will have equipment coated with extremely durable two-pack products with enhanced chemical resistance which is a desirable operational requirement for the military.

The work has also highlighted that, in general, the performance of the single-pack products tested do not match that of the current solvent based paints with the high solids samples offering more potential than water based materials at this stage. It should be remembered, however, that water based products are more desirable from an environmental point of view as they reduce solvent levels (VOC content) to the bare minimum.

Although current single-pack materials do not meet the performance required and further product development is needed by paint manufacturers this is readily recognised by the paint industry and all manufacturers are investing heavily in the production of new materials as replacements for solvent based paints. In fact one of the problems with assessing the performance of compliant paint schemes is that laboratory work would commence on the samples supplied by manufacturers and newer improved products would be offered prior to completion - it is a rapidly changing scene.

The impact of the move towards compliant coatings also requires the MOD user to carefully consider the particular purpose of a paint scheme. With solvent based coatings a particular material could be used in a wide range of applications. For example, material conforming with Defence Standard 80-41 is used to paint various military vehicles as well as static ground support equipment sited in the middle of airfields. Current compliant coatings do not show such versatility and in future different materials may need to be used for the different situations. This presents a problem with regard to an increase in the inventory of paints held and may lead to different process instructions for the different materials. It is important that expert advice is sought during deliberations on such changes. It is easy to specify single source, proprietary materials but for continuity of supply, assurance of product quality and to assist with competitive tendering the use of performance standards (e.g. Defence Standards) is essential.

REFERENCES

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- 2 Hitchen C, Standards development to meet the environmental challenge in painting military vehicles, *Standards in Defence News, Serial 166, August 1998*
- 3 Secretary of State's Guidance - Coating & Recoating of Aircraft & Aircraft Components, *HMSO*
4. Townsend L, Towards more friendly paints, *Coatings on The Move Seminar Surcon '97*

Note: Defence Standards are obtainable from the Directorate of Standardization, Room 1138, Kentigern House, 65 Brown Street, Glasgow, G2 8EX, UK.
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